Application and optics concepts for scanning and full-field X-ray microscopy with multilayer Laue lenses

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Introduction and Objectives

Multilayer Laue lenses (MLL) are an emerging type of X-ray lenses that are fabricated by thin film deposition of multiple layers obeying the zone plate law on a smooth substrate and by subsequent micromachining such as focused ion beam milling. This technological approach results in very small zone widths down to single nanometers and virtually unlimited aspect ratios. Thus, enhancements in terms of efficiency and resolution are expected in particular for hard X-ray applications. We report (a) on recent results of the characterization of crossed and wedged MLLs using scanning X-ray microscopy, and (b) on an alternative condenser concept using MLLs for full-field X-ray microscopy with high photon energies.

Results and Discussion

We manufactured a multilayer stack consisting of 7000 individual layers to obtain MLLs with a focal length of 6.7 mm at 10.5 keV X-ray photon energy using WSi_2 and Si as alternating absorber and spacer materials. From this multilayer stack, several flat and wedged [1] MLL segments were manufactured. Both types were then used for point focusing experiments at beamline ID 13 of ESRF. With focal spot sizes of 33 nm × 28 nm and 43 nm × 44 nm reconstructed by ptychography [2], both types provided nearly diffraction limited focusing for their respective apertures of 23 × 23 µm² and 15 × 15 µm² [3].

It was shown that MLLs are potential novel optics for full-field X-ray microscopy [4]. The illumination of the object plane can be optimized, if the monocapillary is replaced by a multilayer mirror based condenser. This setup is characterized by a better matching of the numerical apertures of condenser and MLL, a decent monochromatization, and the applicability of photon energies $E > 10$ keV.

References

[1] S. Niese et al. "Fabrication of customizable wedged multilayer Laue lenses by adding a stress layer." Thin Solid Films 571 (2014): 321-324.

[2] S. Hönig et al. "Full optical characterization of coherent x-ray nanobeams by ptychographic imaging." Optics Express 19.17 (2011): 16324-16329.

[3] A. Kubec et al. "Focusing Properties of Crossed Wedged Multilayer Laue Lenses." ESRF Experimental reports (2014).

[4] S. Niese et al. "Full-field X-ray microscopy with crossed partial multilayer Laue lenses." Optics Express 22 (2014): 20008-20013.